INDOOR AIR QUALITY ASSESSMENT

Norwood Town Hall
566 Washington Street
Norwood, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program

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Background/Introduction

At the request of Phyllis Boucher, Director, Norwood Board of Health (BOH), the Massachusetts Department of Public Health (DPH), Bureau of Environmental Health Assessment (BEHA) conducted an indoor air quality assessment at the Norwood Town Hall (NTH), 566 Washington Street, Norwood, Massachusetts. Employee concerns about indoor air quality prompted the investigation (Carroll, 2003). On December 30, 2003, Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), made a visit to this building. Eleanor McGonagle, Human Resources Director, Ms. Boucher and various Norwood town officials accompanied Mr. Feeney during the visit.

The NTH is a two-story, stone building located in downtown Norwood. Both the attic and basement/ground floor contain town offices. The building consists of two wings that are joined in an "L" shape, with a bell tower at the joint of the wings. The date of construction is estimated to be 1927. The NTH has undergone several renovations since its original construction, prior to occupancy by the BOH. Yhe 1970s renovations included the installation of an air conditioning system was installed. In addition, the building interior was remodeled and a suspended ceiling was also installed beneath the original ceiling, most likely as an energy conservation measure. In 1987, an elevator was installed in the building; in 1997, offices were constructed within the original open attic; and finally in 2000, the exterior stonework was repointed. Sash windows are openable in the building. Window systems are reportedly planned to be replaced within the next year.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The NTH has an employee population of 60 and is visited by several hundred visitors daily. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million parts of air (ppm) in four of twenty-four areas sampled, which indicates inadequate ventilation in some of the areas tested. During the assessment, air-handling units (AHUs) on the top floor were the only heating, ventilating and air-conditioning (HVAC) systems operating. The HVAC system installed on the lower floors is used solely for air-conditioning during hot weather. At the time of assessment, natural ventilation was the sole source of fresh air. In most of the building, fresh air was provided by air penetrating through cracks and seams around window frames, open windows and the periodic opening of exterior doors.

The mechanical ventilation system appears to be the original equipment that was installed during the construction of the NTH. A deactivated fan and motor that serviced the AHU were found in a records storage area of the attic (Picture 1). A variety of open vents that appear to be part of the original ventilation system were found in offices (Pictures 2 and 3). No fresh air intakes or equipment related to the original mechanical ventilation system could be identified on the ground floor.

The attic offices have ventilation provided by a natural gas fueled AHU, which is located in a mechanical room/closet. The AHU is connected to ductwork located above the ceiling. The ductwork distributes air to ceiling mounted air diffusers throughout the attic space. Air is returned to the mechanical room AHU via ducted return vents.

The main offices are serviced by HVAC units located within each office (Picture 4). Ductwork connects the HVAC units to ceiling mounted air diffusers. Neither fresh air intakes nor return ductwork could be identified for this system. Air is returned through a vent that exists in the front of the AHUs. The room is, in essence, a large duct, with air drawn from the farthest point of the office to the AHU through the office space. In an effort to provide some air circulation, a number of ceiling tiles have been replaced with plastic grates. These grates were installed to allow heat to exhaust into the ceiling plenum or to facilitate the draw of air to the AHU. Any normally occurring pollutants that exists in the ceiling plenum or is generated within offices is drawn and concentrated at the return vent of the AHU. In addition, this type of HVAC system design likely also draws air from the open ductwork of the original, abandoned duct system that exists in the building.

In order to have proper ventilation with a mechanical supply and exhaust system, the ventilation systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of balancing of the attic HVAC system was believed to have occurred after installation (2002). The date of balancing of the ventilation system in the remainder of the building was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see Appendix A.

Temperature readings were measured in a range of 70^{o} F to 78^{o} F, which were within the BEHA recommended comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Temperature control is difficult in an old building operating without a functioning ventilation system.

Relative humidity measurements ranged from 30 to 54 percent, which were below the BEHA comfort range in some areas. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity measurements would be expected to be near or below the relative humidity outdoors. Relative humidity levels would be expected to drop during the heating season. The sensation of dryness and irritation is common in a low relative humidity environment. Humidity is more difficult to control during the winter heating season. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Of note were the conditions of books in the Assessor's Office vault. A number of books had a distinct musty odor. It is possible that some individuals with mold hypersensitivity may become symptomatic when handling these materials. In addition, the vault is located near a ceiling grate and in close proximity to an area that is serviced by the air-conditioning system. As previously discussed, the air-conditioning system uses office space as a return duct. Mold and spores released from handling these materials can become airborne and be entrained by the HVAC system. Since the ventilation system recirculates air, mold related materials from these books could be distributed to other areas/offices.

Another potential source of odors within the NTH is the configuration of the air conditioning AHUs. Each AHU is equipped with a drain that removes condensation from the AHU cabinet generated by cooling coils during air conditioning (Picture 5). This drain is connected to a pipe system that contains a trap. The trap, or u-bend, fills with water, which creates a seal that prevents the draw of particles and odors from the drain system by the fans of the AHU. The trap dries out during the heating season and does not fill with water until the AHU is activated for cool air-conditioning,. As a result, the AHU fans can draw air from the drains. During the initial start up, air from the drain system can be captured by the AHU fans and distributed into occupied areas.

Efflorescence was present under windows in some offices (Picture 6). Efflorescence is a characteristic sign of water damage to brick and mortar, but it is not mold growth. As moisture penetrates and works its way through mortar around brick, water-soluble compounds in bricks and mortar dissolve, creating a solution. As the solution moves to the surface of the brick or mortar, the water evaporates, leaving behind white, powdery mineral deposits. The areas with efflorescence appeared to be historic, rather than active and were in walls made from plaster, which is generally resistant to mold growth. Repointing of the exterior walls and the planned replacement of windows will prevent further water intrusion.

A factor that may be contributing to moisture noted in the basement is water accumulation along the base of the building. The following conditions can lead to subsequent water accumulation along the base of the building, which can subsequently lead to moisture penetration into the basement:

- Damaged downspout located on the front of the building (Picture 7).
- Shrubbery along the front of the building in direct contact with the exterior wall brick (Picture 8). Shrubbery can serve as a possible source of water impingement on the exterior curtain wall due to the location of plants growing directly against the building. Plants retain water and in some cases can work their way into mortar and brickwork causing cracks and fissures, which may subsequently lead to water penetration and possible mold growth.

Each of these conditions allows for the accumulation of water along the base of the building, which can lead to moisture penetration into the basement.

Some water damaged ceiling tiles were also observed in the building. Ceiling tiles can be susceptible to mold growth if allowed to remain moist. If mold has colonized ceiling tiles, the addition of moisture can result in increased mold growth. The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24-48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). Water-damaged ceiling tiles cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy ceiling tiles is not recommended.

Several areas contained plants. Moistened plant soil, drip pans and standing water can serve as a source of mold growth. Plants should be equipped with drip pans and over watering should be avoided. Water coolers are located in several areas directly on carpeting. As previously noted, porous materials that are repeatedly wet can serve as media for mold growth.

An old humidifier was found in the Engineers' Office (Picture 9). Humidifiers should be cleaned regularly and be maintained as per the manufacturer's instructions to avoid bacterial/microbial growth (EPA, 1991). Care should also be taken in the placement of humidifiers to avoid the repeated saturation of porous material(s), which may also lead to mold growth.

Other Concerns

Several other conditions were noted during the assessment, which can adversely affect indoor air quality. Of note was the abandoned ventilation system. Under certain circumstances, the abandoned ductwork can serve as a pathway for odors and particulates to migrate between rooms and floors.

Air-conditioning AHUs in a number of areas are installed with air filters that provided minimal filtration of respirable dust and did not fit flush with their racks (Picture 4). Filters should be one piece that fits flush with the filter rack. If two filters are to be used, the filter rack must have the appropriate equipment to make each filter fit flush in the rack. Air drawn into the AHU will bypass filters through spaces between filters and racks. This can result in dust, dirt and other debris being distributed by the ventilation system. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed in the AHUs. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, 2000; MEHRC, 1997; ASHRAE, 1992). Note, increased resistance from increased filtration can reduce airflow. Prior to any increase of filtration, a ventilation engineer should evaluate each AHU to ascertain whether the unit can maintain function with more efficient filter.

A restroom contained upholstered furniture. Upholstered furniture is covered with fabric that comes in contact with human skin. This type of contact can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. In addition, if relative humidity levels increase above 60 percent, dust mites tend to proliferate (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, 1994). It is also recommended that upholstered furniture be professionally cleaned on an annual basis. If an excessively dusty environment exists due to outdoor conditions or indoor activities (e.g., renovations), cleaning frequency should be increased (every six months) (IICR, 2000). Elevated outdoor levels of airborne particulates can result in increased levels of indoor particulates by entering into the building through open windows, doors and filter bypass.

Finally, it is worthy to note the amount of materials stored in offices. Items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) also make it difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Permanently seal openings for the original ventilation system.
2. Replace plastic grates in the suspended ceiling with solid tiles.
3. Continue with plans to replace windows.
4. Prior to start up of air-conditioning AHUs, pour a full glass of water into each unit's condensation drain to fill the trap.
5. Temporarily store water-damaged or musty vault records and documents inside plastic storage containers with a sealable lid. A decision should be made concerning the storage of mold contaminated legal books/documents. Porous materials can continue to be a source of mold-associated particulates. In this case, dehumidification and ventilation alone cannot serve to reduce or eliminate mold growth in these materials. As an initial step, options concerning the preservation of materials stored in this area should be considered. Since many historical records appear to be stored, an evaluation concerning disposition of these

materials must be made. Porous materials that are judged not worthy of preservation, restoration or transfer to another media (e.g., microfiche or computer scanning) should be discarded. Where stored materials are to be preserved, restored or otherwise handled, an evaluation should be done by a professional book/records conservator. This process can be rather expensive, and may be considered for conservation of irreplaceable documents that are colonized with mold. Due to cost of book conservation, disposal or replacement of moldy materials may be the most economically feasible option.

6. Adopt scrupulous cleaning practices. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations). Consider obtaining a vacuum cleaner equipped with a high efficiency particulate arrestance (HEPA) filter to trap respirable dusts.

7. Consider installing one-piece air filters in air conditioning AHUs with improve dust spot efficiency. Note that increased filtration can reduce airflow produced by the AHU by increased resistance. Prior to any increase of filtration, each AHU should be evaluated by a ventilation engineer as to whether the heat AHU can maintain function with more filters that are efficient.

8. Consider the following actions to prevent moisture penetration into the basement:

a. Remove foliage to no less than five feet from the foundation.

b. Improve the grading of the ground away from the foundation at a rate of 6 inches per every 10 feet (Lstiburek, J. & Brennan, T.; 2001).

c. Install a water impermeable layer on ground surface (clay cap) to prevent water saturation of ground near foundation (Lstiburek & Brennan, 2001).

9. Clean upholstered furniture on the schedule recommended in this report. If not possible/practical, remove upholstered furniture from classrooms.

10. Consider reducing the number of plants indoors if feasible. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.

11. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

12. Discontinue the use of the humidifier in the engineers office.

13. Refer to the resource manual and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These documents are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

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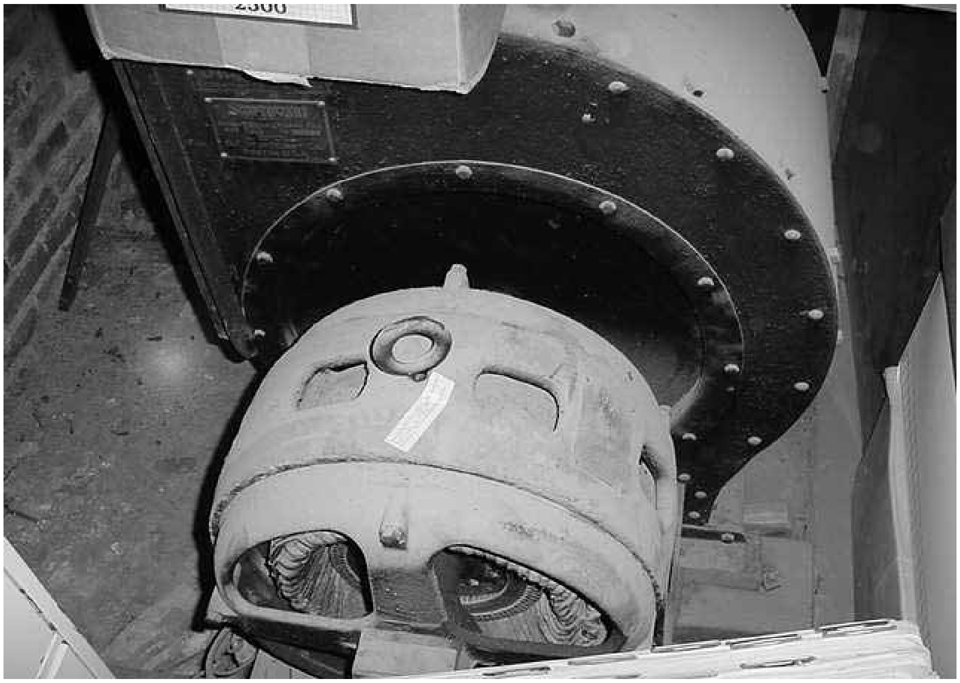
Picture 1

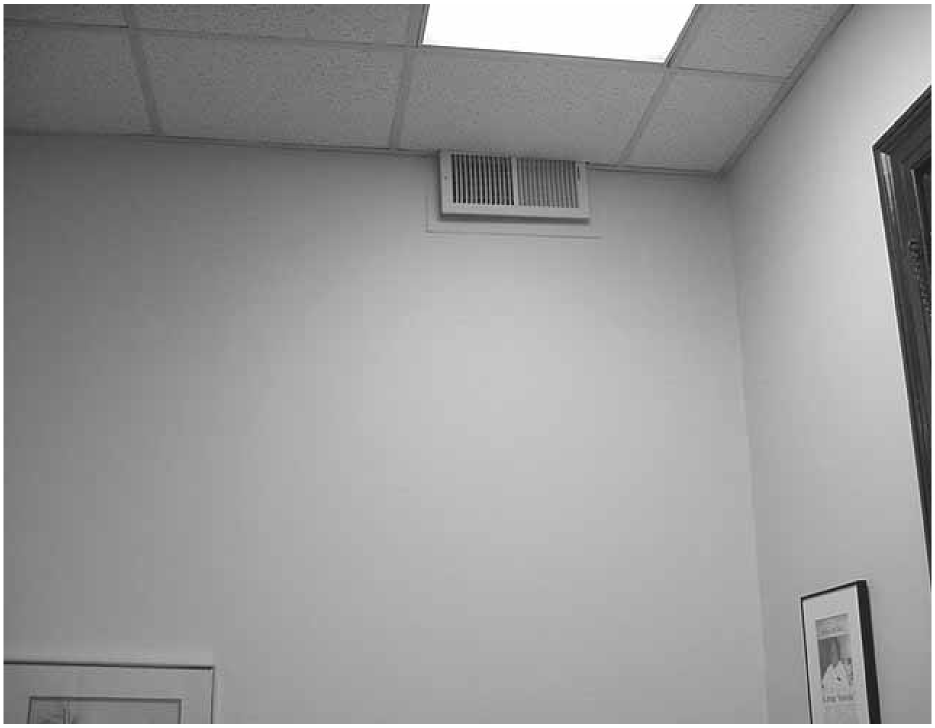


Deactivated Fan and Motor Found In A Records Storage Area In The Attic

Picture 2

Open Vents Found In Offices That Appear To Be Part Of The Original Ventilation System

Picture 3

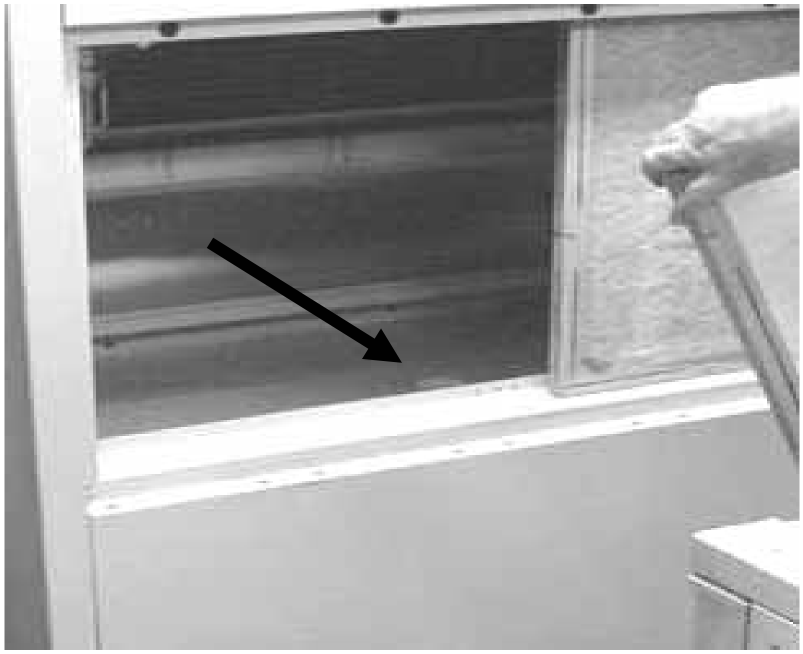


Open Vents Found In Offices That Appear To Be Part Of The Original Ventilation System

Picture 4

Air Conditioning Air Handling Unit, Note Two Filters

Picture 5



Condensation Drain In Air Conditioning AHU

Picture 6

Efflorescence Was Present Under Windows In Some Offices

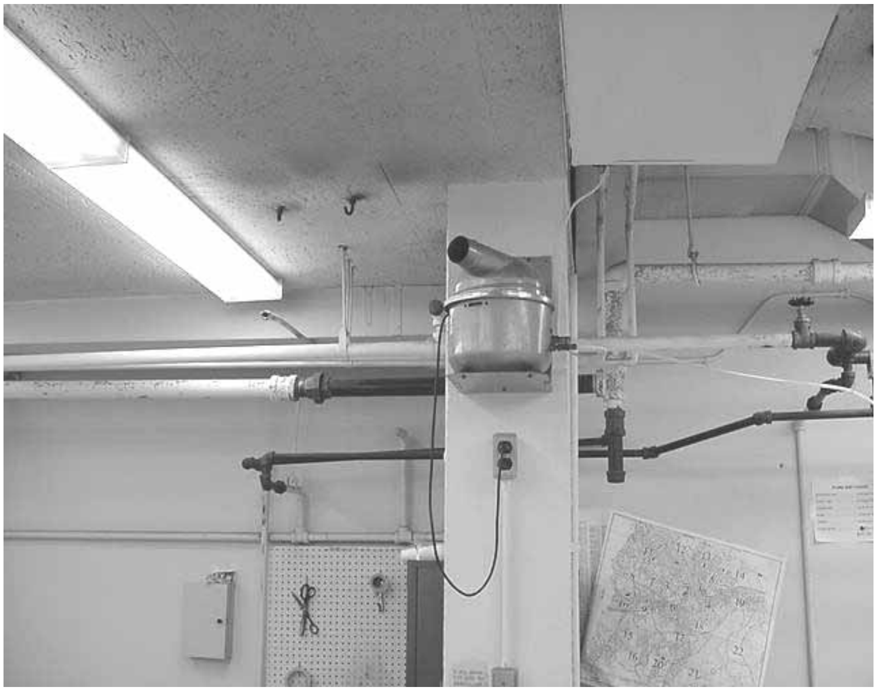
Picture 7

Damaged Downspout

Picture 8

Shrubbery In Direct Contact With The Exterior Wall

Picture 9



An Old Humidifier Was Found In The Engineers Office

Building: Norwood Town Hall
Address: Norwood, MA

Indoor Air Test Results
Date: 12/30/03

TABLE 1

Location/Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Background		52	62	340				
Retirement Board	1	70	54	630	Y	Y	Y	
Computer Room Office	0	71	48	522	Y	Y	Y	Water cooler on carpet
Mainframe Room	1	71	44	525	Y	Y	Y	
Computer Director	0	72	42	440	Y	Y	Y	
Selectmen's Office	2	71	42	633	Y	N	N	Efflorescence windows
Assessor's Office 37	1	74	37	530	Y	N	N	Door open, vault-book mold
36	1	74	34	609	Y	N	N	Plants
Town Clerk 32	1	75	34	619	Y	N	N	Efflorescence
Accounting 36	6	77	33	852	Y	N	N	Plants, Door open, efflorescence, clutter
Women's RR								Refrigerator, couch
Employee Lounge	1	73	32	578	Y	Y	Y	Door open

ppm = parts per million parts of air

AD = air deodorizer
AHU = air-handling unit
AP = air purifier
AC = air conditioning
CD = chalk dust

CT= ceiling tile
DEM = dry erase marker
DO = door open
MT= missing ceiling tile
PC = photocopier

PF = personal fan
TB = tennis balls
UF = upholstered furniture
WD = water damage
ND = non-detect

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Building: Norwood Town Hall | **Indoor Air Test Results**
Address: Norwood, MA | **Date: 12/30/03**

TABLE 1

Location/Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Treasurer's Office	4	73	37	805	Y	Y	Y	Plastic grate in ceiling
Treasurer's Office (back room)	1	78	32	865	Y	Y	Y	Cleaners, white-out
Finance Commissioner 24	0	76	30	587	Y	Y	Y	Water cooler
Town Manager Reception	2	75	31	697	Y	Y	Y	Door open, water cooler
Purchasing	1	76	31	610	Y	Y	Y	Door open
Town Mgr Office	0	75	30	595	Y	Y	Y	Passive vent-sealed
Meeting Rm								
Engineering	2	74	33		Y	Y	Y	Humidifier
Dental Office	0	73	34	625	Y	Y	Y	
Nurse's Office	1	73	33	559	Y	Y	Y	
11	0	73	37	664	Y	Y	Y	Door open
12	1	74	34	743	Y	Y	Y	

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Address: Norwood, MA

Indoor Air Test Results
Date: 12/30/03

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						Supply	Exhaust	
Board of Appeals	1	74	33	806	Y	Y	Y	2 CT
Building Inspector	2	73	30	798	Y	Y	Y	Door open
Veterans Services	1	74	33	721	Y	Y	Y	
Human Resources	1	73	30	545	Y	Y	Y	

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